Section 2

Integrating Mathematics

Studying Populations

Reading Preview

Key Concepts

- How do ecologists determine the size of a population?
- What causes populations to change in size?
- What factors limit population growth?

Key Terms

- estimate
- birth rate
- death rate
- immigration
- emigration
- population density
- limiting factor
- carrying capacity

Target Reading Skill

Asking Questions Before you read, preview the red headings. In a graphic organizer like the one below, ask a question for each heading. As you read, write the answers to your questions.

Studying Populations

Question	Answer
How do you determine population size?	Some methods of determining population size are . . .

Lab zone Discover Activity

What's the Population of Beans in a Jar?

1. Fill a plastic jar with dried beans. This is your model population.
2. Your goal is to determine the bean population size, but you will not have time to count every bean. You may use any of the following to help you: a ruler, a small beaker, another large jar. Set a timer for two minutes when you are ready to begin.
3. After two minutes, record your answer. Then count the beans. How close was your answer?

Think It Over

Forming Operational Definitions In this activity, you came up with an estimate of the size of the bean population. Write a definition of the term *estimate* based on what you did.

How would you like to be an ecologist today? Your assignment is to study the albatross population on an island. One question you might ask is how the size of the albatross population has changed over time. Is the number of albatrosses on the island more than, less than, or the same as it was 50 years ago? To answer this question, you must first determine the current size of the albatross population.

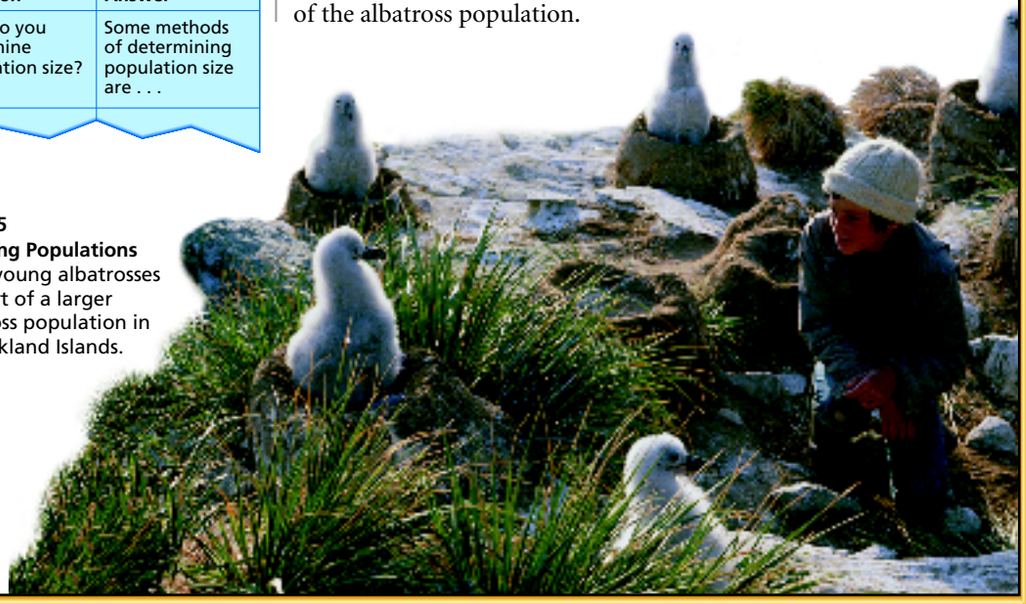


FIGURE 5
Studying Populations
These young albatrosses are part of a larger albatross population in the Falkland Islands.

Lab zone Discover Activity

Skills Focus Forming operational definitions L2

Materials 2 large plastic jars, dried beans, ruler, small beaker, timer

Time 10 minutes

Expected Outcome Possible methods: (1) Fill the small beaker with beans, count the beans, estimate how many small beakers would fit into the large jar, multiply the bean count by that number. (2) Put a 1-cm layer of beans in the second large jar, count the beans, measure the height of the jar, multiply the height by the number of beans in one layer.

Think It Over Definitions should focus on the idea of making an informed or educated guess.

Section 2

Studying Populations

Objectives

After this lesson, students will be able to

E.1.2.1 Describe methods for determining the size of a population.

E.1.2.2 Explain the causes of changes in population size.

E.1.2.3 Identify factors that limit population growth.

Target Reading Skill

Asking Questions Explain that changing a head into a question helps students anticipate the ideas, facts, and events they are about to read.

Answers

Possible student question and answers are these: **How do you determine population size?** *(Some methods of determining population size are direct observation, indirect observation, sampling, and mark-and-recapture studies.)* **What causes populations to change in size?** *(Some factors include birth, death, immigration, and emigration.)* **What are limiting factors?** *(These are factors that can limit population growth if they are unfavorable for the organisms in the population. Food and water, space, and weather conditions can be limiting factors.)*

All in One Teaching Resources

- Transparency E3

Preteach

Build Background Knowledge L2

Experience with Mark-and-Recapture

Ask: **Have you ever seen scientists in a television documentary capture a wild animal, such as a wolf, bear, or bird, and then tag it with a specific color or mark and release it? What was the purpose of this procedure?** *(Answers might include to count the number of individuals in a population.)* Tell students that this is only one technique that scientists use to find the number of individuals in a population.

Instruct

Determining Population Size

Teach Key Concepts L2

Estimating

Focus Remind students that a population is all the members of a species living in a particular area.

Teach Ask: **Why might scientists want to determine the number of individuals in a population?** *(Possible answer: To see if a population is increasing or decreasing)* Review the techniques for determining population size by direct and indirect observation, sampling, and mark-and-recapture studies.

Apply Ask students what method they would use to count the number of individuals in the following populations: grizzly bears in a national park, grasshoppers in a field, and herons on a large pond. Have students give reasons for their answers. *(Possible answers: grizzly bears: indirect observation because there are few, they are difficult to capture, and they would be spread over a large area; grasshoppers: sampling because there would be too many to count individually; herons: direct observation because only a few would live in the same pond)* **learning modality: logical/mathematical**

Independent Practice

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Studying Populations*

Student Edition Audio CD

Determining Population Size

Some methods of determining the size of a population are direct and indirect observations, sampling, and mark-and-recapture studies.

Direct Observation The most obvious way to determine the size of a population is to count all of its members. For example, you could try to count all the crabs in a tide pool.

Indirect Observation Sometimes it may be easier to observe signs of organisms rather than the organisms themselves. Look at the mud nests built by cliff swallows in Figure 6. Each nest has one entrance hole. By counting the entrance holes, you can determine the number of swallow nests in this area. Suppose that the average number of swallows per nest is four: two parents and two offspring. If there are 120 nests, you can multiply 120 by 4 to determine that there are 480 swallows.

Sampling In many cases, it is not even possible to count signs of every member of a population. The population may be very large or spread over a wide area. In such cases, ecologists usually make an estimate. An **estimate** is an approximation of a number, based on reasonable assumptions.

FIGURE 6
Determining Population Size
Scientists use a variety of methods to determine the size of a population.

Direct Observation
Counting these crabs one by one is an example of direct observation.

Indirect Observation
One way to determine this cliff swallow population is to count their cone-shaped nests.

Differentiated Instruction

Gifted and Talented L3

Researching Population Studies Have students research specific population studies around the world. Ask them to prepare a 10–15 minute oral report for the class that tells what is being studied, where and why the study is taking place, and who is doing the study. Tell them to include a description of the methods that are being used. Encourage students to include pictures, diagrams, and graphs to explain their information. **learning modality: logical/mathematical**

Special Needs L1

Practice Calculations For students who need extra help with the Math Skills activity, provide additional examples so that they can practice the calculations; for example, 144 dandelion plants in a lawn 12 m long and 6 m wide. *(2 plants per m^2)* You may want to let students use calculators to solve the problems. Also, invite students to make up problems for the class to solve.

One way to estimate the size of a population is to count the number of organisms in a small area (a sample), and then multiply to find the number in a larger area. To get the most accurate estimate, your sample area should be typical of the larger area. Suppose you count 8 birch trees in 100 square meters of a forest. If the entire forest were 100 times that size, you would multiply your count by 100 to estimate the total population, or 800 birch trees.

Mark-and-Recapture Studies Another estimating method is called "mark and recapture." Here's an example showing how mark and recapture works. First, turtles in a bay are caught in a way that does not harm them. Ecologists count the turtles and mark each turtle's shell with a dot of paint before releasing it. Two weeks later, the researchers return and capture turtles again. They count how many turtles have marks, showing that they have been recaptured, and how many are unmarked. Using a mathematical formula, the ecologists can estimate the total population of turtles in the bay. You can try this technique for yourself in the Skills Lab at the end of this section.

Reading Checkpoint **When might an ecologist use indirect observation to estimate a population?**

Lab zone **Skills Activity**

Calculating

An oyster bed is 100 meters long and 50 meters wide. In a 1-square-meter area you count 20 oysters. Estimate the population of oysters in the bed. (*Hint:* Drawing a diagram may help you set up your calculation.)

Sampling
To estimate the birch tree population in a forest, count the birches in a small area. Then multiply to find the number in the larger area.

Mark and Recapture
This researcher is releasing a marked turtle as part of a mark-and-recapture study.

Lab zone **Build Inquiry** L2

Estimating a Population

Materials 500 wooden toothpicks

Time 15 minutes

Focus Tell students that in this activity they will estimate the population of toothpicks.

Teach Scatter 500 toothpicks over a rectangular area large enough to provide a 1-square-meter section for each student, or use a floor with 1-ft-square tiles, allowing one tile per student. Tell students the total area but not the number of toothpicks you used. Have each student estimate the number of toothpicks in his or her "sample" and then calculate the total "population" of toothpicks. Write the estimates on the board.

Apply Ask: **Why did the estimates vary?** *(Sampling methods may have varied slightly. Different samples contained different numbers of toothpicks.)* **Which techniques does this activity model?** *(Sampling)* **Do you think this is the best way to determine the population of toothpicks? Why?** *(Accept all answers that show logical thinking. Most students will agree that sampling is the best method for counting the toothpicks because the total number is large, and it would take a lot of time to count individuals.)* **learning modality: kinesthetic**

Lab zone **Skills Activity**

Skills Focus Calculating L2

Materials none

Time 5 minutes

Tips If necessary, review the formula for finding area: length × width = area.

Expected Outcome The total population is 100,000 oysters (100 m × 50 m = 5,000 m^2 × 20 oysters per m^2).

Extend Ask: **Why is your answer only an estimate of the total population?** *(Every square meter may not have exactly 20 oysters.)* **learning modality: logical/mathematical**

Monitor Progress L2

Oral Presentation Write descriptions of various populations on index cards. Have each student choose a card and tell what method they would use to determine the population size.

Answer

Reading Checkpoint Scientists might use indirect observation when a population is small or difficult to find.

Changes in Population Size

Teach Key Concepts L2

Emigration and Immigration

Focus Ask: **What might happen to the size of a particular population over time?** *(It might increase or decrease.)*

Teach Discuss with students the meanings of *immigration* and *emigration*. Ask: **What might cause individuals to immigrate?** *(Possible answers might include an abundant food supply.)* **Why might individuals emigrate?** *(Students might suggest drought, food scarcity, or habitat destruction.)*

Apply Ask: **Why might scientists want to monitor the size of a population?** *(Possible answers: To make sure the population isn't getting too large, which could lead to habitat destruction; to see if a population is at risk of becoming endangered)*

Extend The Active Art shows students how populations change over time. **learning modality: verbal**

All in One Teaching Resources

- Transparency E4

Math Skills

Math Skill Inequalities

Focus Ask students what the term *inequality* means. *(Not equal in amount, size, value, and so on)*

Teach Direct students' attention to the symbols for "greater than" and "less than." Point out that the smaller value appears on the side of the symbol that forms the point. The larger value is placed on the side with the open end.

Answers

1. $5 > -6$

2. $0.4 < \frac{3}{5}$

$\frac{2}{5} < \frac{3}{5}$

$0.4 < 0.6$

3. $-2 - (-8) > 7 - 1.5$

$6 > 5.5$

Changes in Population Size

By returning to a location often and using one of the methods described on the previous page, ecologists can monitor the size of a population over time. **Populations can change in size when new members join the population or when members leave the population.**

Births and Deaths The main way in which new individuals join a population is by being born into it. The **birth rate** of a population is the number of births in a population in a certain amount of time. For example, suppose that a population of 100 cottontail rabbits produces 600 young in a year. The birth rate in this population would be 600 young per year.

The main way that individuals leave a population is by dying. The **death rate** is the number of deaths in a population in a certain amount of time. If 400 rabbits die in a year in the population, the death rate would be 400 rabbits per year.

The Population Statement When the birth rate in a population is greater than the death rate, the population will generally increase. This can be written as a mathematical statement using the "is greater than" sign:

If birth rate > death rate, population size increases.

However, if the death rate in a population is greater than the birth rate, the population size will generally decrease. This can also be written as a mathematical statement:

If death rate > birth rate, population size decreases.

Immigration and Emigration The size of a population also can change when individuals move into or out of the population, just as the population of your town changes when families move into town or move away. **Immigration** (im ih GRAY shun) means moving into a population. **Emigration** (em ih GRAY shun) means leaving a population. For instance, if food is scarce, some members of an antelope herd may wander off in search of better grassland. If they become permanently separated from the original herd, they will no longer be part of that population.

Graphing Changes in Population Changes in a population's size can be displayed on a line graph. Figure 7 shows a graph of the changes in a rabbit population. The vertical axis shows the numbers of rabbits in the population, while the horizontal axis shows time. The graph shows the size of the population over a ten-year period.

Math Skills

Inequalities

The population statement is an example of an inequality. An inequality is a mathematical statement that compares two expressions. Two signs that represent inequalities are

< (is less than)

> (is greater than)

For example, an inequality comparing the fraction to the decimal 0.75 would be written

$$\frac{1}{2} < 0.75$$

Practice Problems Write an inequality comparing each pair of expressions below.

1. $5 \blacksquare -6$

2. $0.4 \blacksquare \frac{3}{5}$

3. $-2 - (-8) \blacksquare 7 - 1.5$

Differentiated Instruction

English Learners/Beginning L1
Vocabulary: Word Analysis Write the words *immigration* and *emigration* on the board and circle *migration* in each. Explain that *migration* means "traveling from one place to another." Tell students that the prefix *im-* is similar in meaning to the word *in*, so *immigration* means "in-migration." Then explain that when they see the prefix *e-*, students can think of *exit*, so *emigration* means "out-migration." Demonstrate these meanings by leaving the room and walking back into it, stating the words as you do each act. **learning modality: verbal**

English Learners/Intermediate L2
Vocabulary: Word Analysis Use the procedure for Beginning students, but have students write sentences using the words *immigration* and *emigration*. **learning modality: verbal**

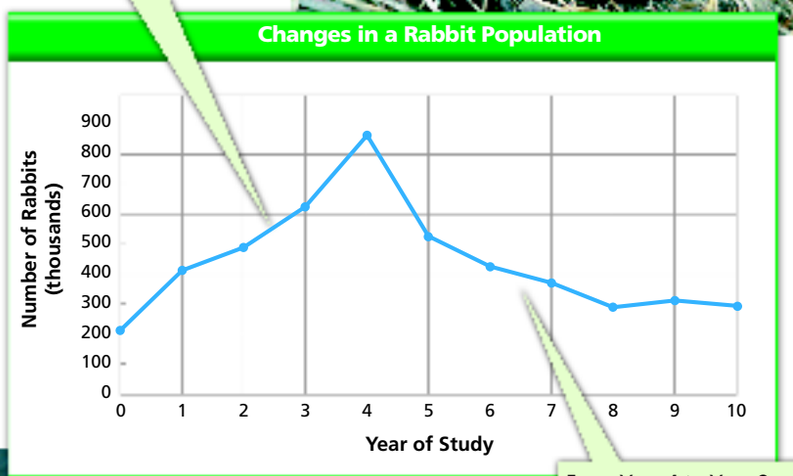
FIGURE 7
This line graph shows how the size of a rabbit population changed over a ten-year period. **Interpreting Graphs** *In what year did the rabbit population reach its highest point? What was the size of the population in that year?*

Go Online active art

For: Changes in Population activity
Visit: PHSchool.com
Web Code: cep-5012

▼ Young cottontail rabbits in a nest

From Year 0 to Year 4, more rabbits joined the population than left it, so the population increased.



From Year 4 to Year 8, more rabbits left the population than joined it, so the population decreased.

◀ Cottontail rabbit caught by a fox

Lab zone Build Inquiry

L2

Calculating Growth Rate

Materials none

Time 5 minutes

Focus Review with students the definitions of *birth rate* and *death rate.*

Teach Ask: **Suppose 1,600 snow geese died in the same year that 1,400 were born. What would the growth rate be for that year?** *(*Tell students that birth rate – death rate = growth rate: b – d = g. *1,400 – 1,600 = growth rate of –200 geese for that year)* **What does a negative growth rate mean?** *(The population is declining.)*

Apply Ask: **What might account for a death rate that is higher than the birth rate?** *(Possible answers: Disease; not enough food; being eaten by other animals; unfavorable environmental conditions)* **learning modality: logical/mathematical**

Go Online active art

For: Changes in Population Activity
Visit: PHSchool.com
Web Code: cep-5012

Students investigate the factors influencing changes in population size.

Differentiated Instruction

Gifted and Talented L3

Calculating Growth Rate Tell students that ecologists use the birth and death rates to calculate a population's growth rate, the rate at which the population is changing. The birth rate *(b)* minus the death rate *(d)* equals the growth rate *(g): b – d = g.* Have students use this formula to calculate the growth rate of rabbits discussed in the text. *(600 births – 400 deaths = a growth rate of 200 rabbits per year)* **learning modality: logical/mathematical**

Monitor Progress

L2

Writing Have each student write a paragraph explaining how birth rate and death rate affect the size of a population. Students can save their paragraphs in their portfolios.

Portfolio

Answer

Figure 7 Fourth year of the study; about 850

Limiting Factors

Teach Key Concepts L2

Inferring Limiting Factors of Plants

Focus Review with students the biotic and abiotic factors that might be found in an organism's habitat. Help students identify the factors that are essential for all living things, such as food, water, space, and appropriate weather conditions.

Teach Ask: **If all the needs of a population are met, what will most likely happen to the size of the population?** *(It will increase.)* **Can the size of the population continue to increase indefinitely? Why?** *(No, because at some time one or more of the factors will become insufficient for the size of the population)* Tell students that any factor that causes a population to decrease is a limiting factor.

Apply Ask: **Is food a limiting factor for plants?** *(No)* **Why not?** *(Plants make their own food.)* **What factors do limit the size of plant populations?** *(The amounts of sunlight, carbon dioxide in the air, water, and nutrients in the soil)* **How do these factors limit plant populations?** *(Plants need light, carbon dioxide, and water to conduct photosynthesis, and they need nutrients for their own life processes.)* **learning modality: logical/mathematical**

All in One Teaching Resources

- Transparency E5

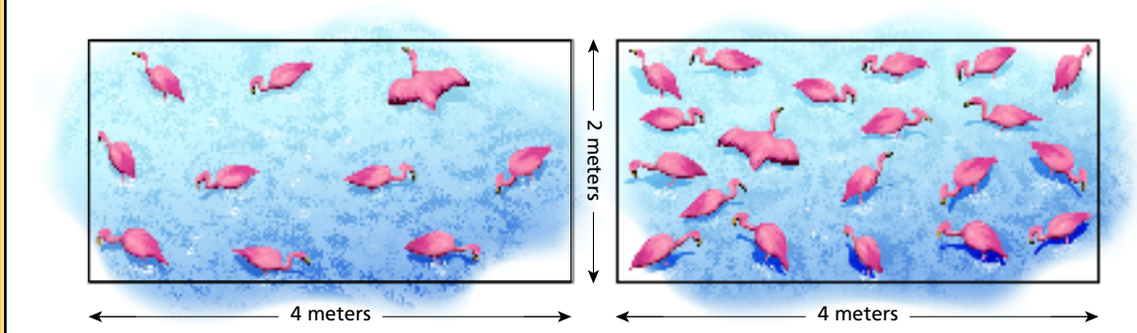


FIGURE 8
Population Density
In the pond on the top left, there are ten flamingos in 8 square meters. The population density is 1.25 flamingos per square meter. **Calculating** *What is the population density of the flamingos in the pond on the top right?*

Population Density Sometimes an ecologist may need to know more than just the total size of a population. In many situations, it is helpful to know the **population density**—the number of individuals in a specific area. Population density can be written as an equation:

$$\text{Population density} = \frac{\text{Number of individuals}}{\text{Unit area}}$$

For example, suppose you counted 20 monarch butterflies in a garden measuring 10 square meters. The population density would be 20 monarchs per 10 square meters, or 2 monarchs per square meter.

Reading Checkpoint **What is meant by the term *population density*?**

Limiting Factors

When the living conditions in an area are good, a population will generally grow. But eventually some environmental factor will cause the population to stop growing. A **limiting factor** is an environmental factor that causes a population to decrease. **Some limiting factors for populations are food and water, space, and weather conditions.**

Food and Water Organisms require food and water to survive. Since food and water are often in limited supply, they are often limiting factors. Suppose a giraffe must eat 10 kilograms of leaves each day to survive. The trees in an area can provide 100 kilograms of leaves a day while remaining healthy. Five giraffes could live easily in this area, since they would only require a total of 50 kilograms of food. But 15 giraffes could not all survive—there would not be enough food. No matter how much shelter, water, and other resources there were, the population would not grow much larger than 10 giraffes.

The largest population that an area can support is called its **carrying capacity.** The carrying capacity of this giraffe habitat would be 10 giraffes. A population usually stays near its carrying capacity because of the limiting factors in its habitat.

Space Space is another limiting factor for populations. Gannets are seabirds that are usually seen flying over the ocean. They come to land only to nest on rocky shores. But the nesting shores get very crowded. If a pair does not find room to nest, they will not be able to add any offspring to the gannet population. So nesting space on the shore is a limiting factor for gannets. If there were more nesting space, more gannets would be able to nest, and the population would increase.

Space is also a limiting factor for plants. The amount of space in which a plant grows determines whether the plant can obtain the sunlight, water, and soil nutrients it needs. For example, many pine seedlings sprout each year in a forest. But as the seedlings grow, the roots of those that are too close together run out of space. Branches from other trees may block the sunlight the seedlings need. Some of the seedlings then die, limiting the size of the pine population.

FIGURE 9
Food as a Limiting Factor
These jackals are fighting over the limited food available to them.

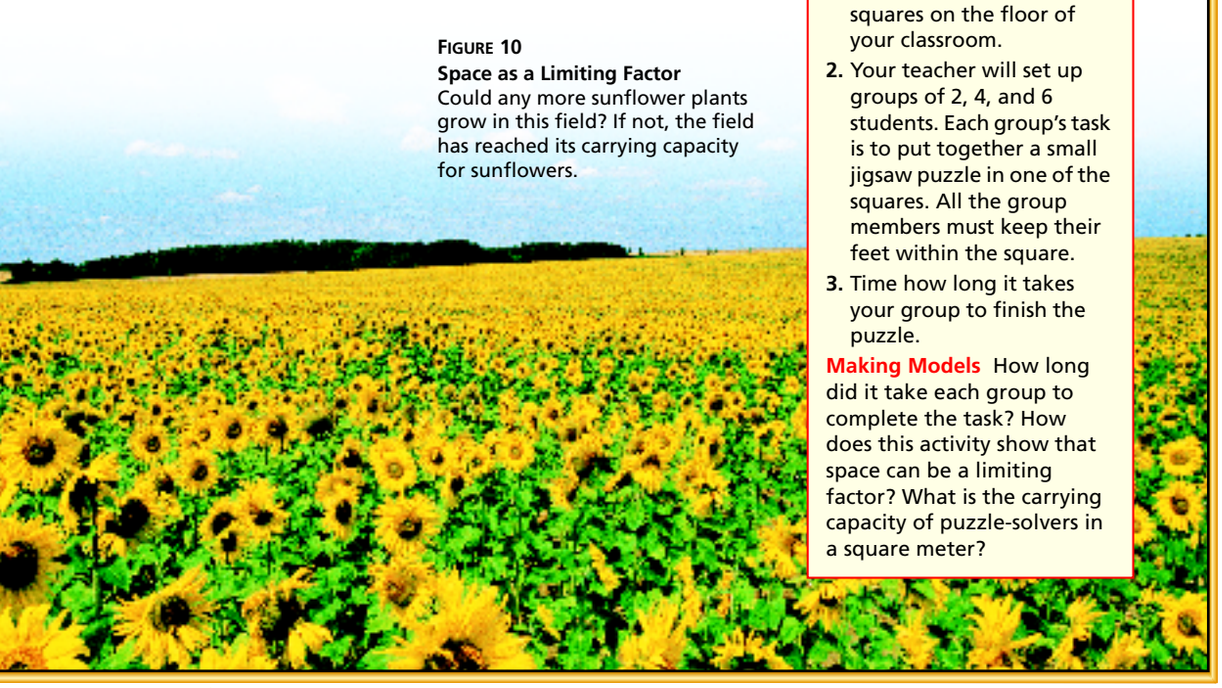


FIGURE 10
Space as a Limiting Factor
Could any more sunflower plants grow in this field? If not, the field has reached its carrying capacity for sunflowers.

Lab zone Try This Activity

Elbow Room

1. Using masking tape, mark off several one-meter squares on the floor of your classroom.
2. Your teacher will set up groups of 2, 4, and 6 students. Each group's task is to put together a small jigsaw puzzle in one of the squares. All the group members must keep their feet within the square.
3. Time how long it takes your group to finish the puzzle.

Making Models How long did it take each group to complete the task? How does this activity show that space can be a limiting factor? What is the carrying capacity of puzzle-solvers in a square meter?

Lab zone Build Inquiry

L2

Exponential Growth

Materials 2 boxes of small paper clips

Time 15 minutes

Focus Tell students that limiting factors help control population growth.

Teach Give small groups of students boxes of paper clips. Tell students that each paper clip represents an amoeba, a one-celled organism that reproduces by splitting in half. Have students show uncontrolled population growth by laying out the paper clips to show growth through six generations. *(The results: Generation 1—1 amoeba; Generation 2—2 amoebas; Generation 3—4 amoebas; Generation 4—8 amoebas; Generation 5—16 amoebas; Generation 6—32 amoebas)* Then tell students that the food supply for the amoebas has become scarce, and some members of each generation will die. Tell students to remove one "amoeba" and its resulting offspring from Generations 4, 5, and 6. Have students compare the numbers of organisms in the last generation of both models.

Apply Discuss how populations can grow out of control without limiting factors. Tell students that under laboratory conditions, a common bacterium, *E. coli,* can reproduce once every 20 minutes. Explain that without limiting factors, one *E. coli* could multiply to a mass twice that of Earth in 48 hours.
learning modality: kinesthetic

Lab zone Try This Activity

Skills Focus Making models

Materials masking tape, meter stick, small jigsaw puzzle, watch or clock

Time 15 minutes

Tips Use very simple puzzles so that puzzle difficulty is not a factor.

L1

Expected Outcome Smaller groups will probably finish their puzzles before groups of six. Crowding in groups of six made the task more difficult.

Extend Invite students to suggest other simple models of space as a limiting factor.
learning modality: kinesthetic

Monitor Progress

L2

Writing Have students write a few sentences telling in their own words what a limiting factor is.

Answers

Figure 8 2.5 flamingos/m^2

Reading Checkpoint Population density is the number of individuals in a specific area.

Monitor Progress L1

Answers

Figure 11 Temperature, amount of rainfall (too much or too little), storms, floods

Reading Checkpoint Possible answers: A cold snap in late spring, a hurricane, a flood

Assess

Reviewing Key Concepts

1. a. direct observation, indirect observation, sampling, mark and recapture **b.** Sampling; there would be too many mushrooms over too large an area to count them individually.

2. a. Join—birth, immigration; leave—death, emigration **b.** 500 mice **c.** Some mice may have immigrated into the population.

3. a. Food and water, space, weather **b.** Any of the following: A population cannot grow beyond the number that can be supported by the amount of food and water available; if organisms do not have enough space, some will not be able to reproduce or survive; severe weather conditions can kill members of a population. **c.** Sample answer: A severely cold winter could kill large numbers of pigeons and reduce the population.

Reteach L1

As a class make a two-column chart. In the first column, list the limiting factors for populations. In the second column, tell how the factor can limit populations.

Performance Assessment

Oral Presentation Call on students to identify a factor that affects the size of a population. *(Birth/death rates, immigration, emigration, limiting factors)*

All in One Teaching Resources

- Section Summary: *Studying Populations* L2
- Review and Reinforcement: *Studying Populations*
- Enrich: *Studying Populations*

FIGURE 11
Weather as a Limiting Factor A snowstorm can limit the size of an orange crop. **Applying Concepts** *What other weather conditions can limit population growth?*

Weather Weather conditions such as temperature and the amount of rainfall can also limit population growth. A cold snap in late spring can kill the young of many species of organisms, including birds and mammals. A hurricane or flood can wash away nests and burrows. Such unusual events can have long-lasting effects on population size.

Reading Checkpoint **What is one weather condition that can limit the growth of a population?**

Section 2 Assessment

Target Reading Skill **Asking Questions** Use the answers to the questions you wrote about the headings to help you answer the questions below.

Reviewing Key Concepts

1. a. **Listing** What are four methods of determining population size?

b. **Applying Concepts** Which method would you use to determine the number of mushrooms growing on the floor of a large forest? Explain.

2. a. **Identifying** Name two ways organisms join a population and two ways organisms leave a population.

b. **Calculating** Suppose a population of 100 mice has produced 600 young. If 200 mice have died, how many mice are in the population now? (Assume for this question that no mice have moved into or out of the population for other reasons.)

c. **Drawing Conclusions** Suppose that you discovered that there were actually 750 mice in the population. How could you account for the difference?

3. a. **Reviewing** Name three limiting factors for populations.

b. **Describing** Choose one of the limiting factors and describe how it limits population growth.

c. **Inferring** How might the limiting factor you chose affect the pigeon population in your town?

Math Practice

4. **Inequalities** Complete the following inequality showing the relationship between carrying capacity and population size. Then explain why the inequality is true.

If population size ■ carrying capacity, then population size will decrease.

Math Practice

Math Skill Inequalities

Answer

4. If population size > carrying capacity, then population size will decrease. The carrying capacity is the largest population an area can support. If there are more individuals than an area can support, then they won't survive and the population will decrease .

Lab zone Skills Lab

Counting Turtles

Problem

How can the mark-and-recapture method help ecologists monitor the size of a population?

Skills Focus

calculating, graphing, predicting

Materials

- model paper turtle population
- calculator
- graph paper

Procedure

1. The data table shows the results from the first three years of a population study to determine the number of snapping turtles in a pond. Copy the table into your notebook.

Data Table

Year	Number Marked	Total Number Captured	Number Recaptured (With Marks)	Estimated Total Population
1	32	28	15	
2	25	21	11	
3	23	19	11	
4	15			

2. Your teacher will give you a box representing the pond. Fifteen of the turtles have been marked, as shown in the data table for Year 4.
3. Capture a member of the population by randomly selecting one turtle. Set it aside.
4. Repeat Step 3 nine times. Record the total number of turtles you captured.
5. Examine each turtle to see whether it has a mark. Count the number of recaptured (marked) turtles. Record this number in your data table.

Analyze and Conclude

1. **Calculating** Use the equation below to estimate the turtle population for each year. The first year is done for you as a sample. If your answer is a decimal, round it to the nearest whole number. Record the population for each year in the last column of the data table.

$$\text{Total population} = \frac{\text{Number marked} \times \text{Total number captured}}{\text{Number recaptured (with marks)}}$$

Sample (Year 1):

$$\frac{32 \times 28}{15} = 59.7 \text{ or } 60 \text{ turtles}$$

2. **Graphing** Graph the estimated total populations for the four years. Mark years on the horizontal axis. Mark population size on the vertical axis.
3. **Interpreting Data** Describe how the turtle population has changed over the four years of the study. Suggest three possible causes for the changes.
4. **Predicting** Use your graph to predict what the turtle population will be in Year 5. Explain your prediction.
5. **Communicating** Write a paragraph that explains why the mark-and-recapture method is a useful tool for ecologists. When is this technique most useful for estimating a population's size?

More to Explore

Suppose that only six turtles had been recaptured in Year 2. How would this change your graph?

Analyze and Conclude

1. The estimated totals for Years 1–3 are 60, 48, and 40. Total number captured for Year 4 is 10. If 0 are recaptured, the total population cannot be determined. If 1 is recaptured, the estimated total is 150; if 2, 75; if 3, 50; if 4, 38; if 5, 30; if 6, 25; if 7, 21; if 8, 19; if 9, 17; if 10, 15.

2. Year 4 will vary.

3. The turtle population declined steadily from Year 1 to Year 3. Possible causes include limited food, overcrowding, weather conditions, disease, predation, and use of chemicals in the pond.

4. Most students will probably predict a continuing decline in the population.

5. Sample answer: Mark and recapture is useful because it allows scientists to study a population over time. It is most useful when a population is fairly large, concentrated in one area, and can't be observed directly or indirectly.

Lab zone Skills Lab

Counting Turtles L2

Prepare for Inquiry

Skills Objectives

After this lab, students will be able to

- calculate the size of a population
- graph population estimates
- predict the size of a future population

Prep Time 20 minutes
Class Time 40 minutes

Advance Planning

Prepare a model population for each group. Use 30 paper squares to represent turtles. Mark a dot on one side of 15 cards. Spread all 30 cards in a box, marked sides down.

All in One Teaching Resources

- Lab Worksheet: *Counting Turtles*

Guide Inquiry

Invitation

Review with students the mark-and-recapture method for determining population size.

Introducing the Procedure

Tell students that each square represents a turtle and that some of the "turtles" have been marked with a dot on one side.

Troubleshooting the Experiment

- In Step 2, clarify that the 15 marked turtles refer to the bottom box in the second column of the table, "Number Marked."
- Students may assume that more turtles recaptured with marks means a bigger population, and fewer turtles with marks means a smaller population. Point out that the opposite is true because unmarked turtles could be new turtles added (birth, immigration) since the last count.

Expected Outcome

The number of marked turtles recaptured will vary. Therefore, students' estimates of the total population of Year 4 will also vary.

More to Explore

The estimated total population would increase to 88.

Science and Society

Animal Overpopulation: How Can People Help?

Key Concept

Food has become a limiting factor for the rapidly growing populations of white-tailed deer in many parts of the United States. People must decide how to reduce the deer populations.

Build Background Knowledge

Recalling Limiting Factors

Help students recall that several factors can limit populations. Ask: **What are some limiting factors for populations?** *(Food, water, space, weather)* **What would be the effect on a population if the food supply is insufficient to support all the individuals?** *(Some individuals will die of starvation.)*

Introduce the Debate

Direct attention to the large picture of the white-tailed deer. Explain that in many areas of the country these animals have no natural predators and, as a result, their populations have increased rapidly. Point out that, in addition, many of their habitats have been destroyed due to land development. Explain that these conditions have made the food supply for many of these populations inadequate. Ask: **What are some ways that the deer population might be controlled?** *(Accept any reasonable responses at this point.)*

Facilitate the Debate

Have students read the feature and answer the You Decide questions individually as a homework assignment. The next day, organize the class into small groups for discussion. Have students consider these questions: **What are the advantages and disadvantages of each proposed action? Which action do you think is in the best interests of the deer? Of other populations in the area? Which solution would you support if your area had a deer overpopulation problem? Why would you choose that solution?** Organize the class into three groups. Arbitrarily assign each group to argue each proposed action. Alternately call on students from each group to state the group's position or refute an idea from someone in the other group.

Animal Overpopulation: How Can People Help?

Populations of white-tailed deer are growing rapidly in many parts of the United States. As populations soar, food becomes a limiting factor. Many deer die of starvation. Others grow up small and unhealthy. In search of food, hungry deer move closer to where humans live. There they eat farm crops, garden vegetables, shrubs, and even trees. In addition, increased numbers of deer near roads can cause automobile accidents.

People admire the grace and swiftness of deer. Most people don't want these animals to suffer from starvation or illness. Should people take action to limit growing deer populations?

White-Tailed Deer
To obtain food, deer are moving into people's yards.

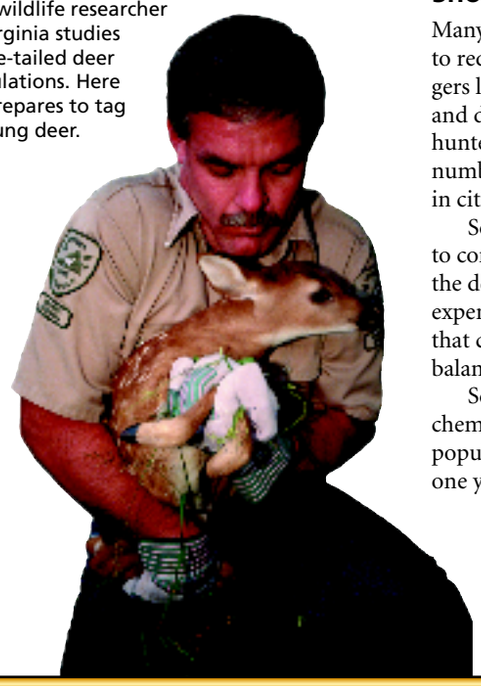
The Issues

Should People Take Direct Action?

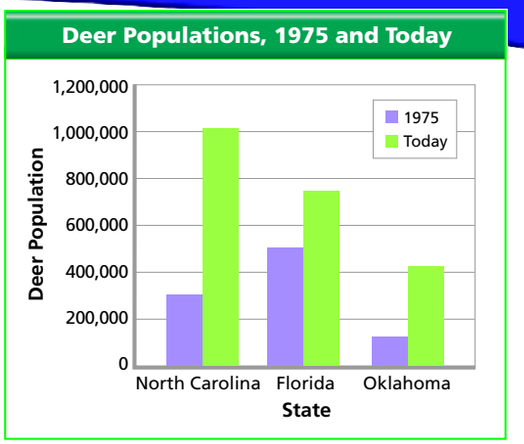
Many people argue that hunting is the best way to reduce animal populations. Wildlife managers look at the supply of resources in an area and determine its carrying capacity. Then hunters are issued licenses to help reduce the number of deer. Hunting is usually not allowed in cities or suburbs, however.

Some people favor nonhunting approaches to control deer populations. One plan is to trap the deer and relocate them. But this method is expensive and requires finding another location that can accept the deer without upsetting the balance of its own ecosystem.

Scientists are also working to develop chemicals to reduce the birth rate in deer populations. But this plan is effective for only one year at a time.



Wildlife Technician
This wildlife researcher in Virginia studies white-tailed deer populations. Here he prepares to tag a young deer.



White-Tailed Deer Populations
This graph shows how the deer populations have grown in North Carolina, Florida, and Oklahoma.

Should People Take Indirect Action?

Some suggest bringing in natural predators of deer, such as wolves, mountain lions, and bears, to areas with too many deer. But these animals could also attack cattle, dogs, cats, and even humans. Other communities have built tall fences around areas to keep out the deer. However, this solution is impractical for farmers or ranchers.

Should People Do Nothing?

Some people oppose any kind of action. They support leaving the deer alone and allowing nature to take its course. Animal populations in an area naturally cycle up and down over time. Doing nothing means that some deer will die of starvation or disease. But eventually, the population will be reduced to a size within the carrying capacity of the environment.

You Decide

1. Identify the Problem
In your own words, explain the problem created by the over-population of white-tailed deer.

2. Analyze the Options
List the ways that people can deal with the overpopulation of white-tailed deer. State the positive and negative points of each method.

3. Find a Solution
Suppose you are an ecologist in an area that has twice as many deer as it can support. Propose a way for the community to deal with the problem.

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You Decide

1. Possible response: Overpopulation results in starvation for many animals; others may grow up unhealthy. In search of limited food, the deer may destroy crops and landscape plants in areas where human live, which can affect other organisms dependent on those plants. Increased numbers of deer also can cause more automobile accidents.
2. Direct actions—*hunting*: inexpensive but many people object to this method and it is impractical in suburban areas where deer are most troublesome; *trapping and relocating:* animals are not killed but the method is expensive and requires finding another location to accept the deer, which can upset the existing balance in the new location; *using chemicals to reduce birth rates:* the chemicals are only effective for one year at a time. Indirect action—*bringing in natural enemies:* predators could attack other animals in the area; *building fences:* impractical for large areas. Do nothing—some deer will die but eventually the population will reduce to within the carrying capacity.
3. Encourage students to provide reasons for their plans.

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Extend

If your community has a problem with animal overpopulation—with deer, gypsy moths, or skunks, for example—suggest that students discuss the issue with family members and, if possible, consult with community and state agencies to find out how people are dealing with the problem.

Background

Facts and Figures Deer overpopulation can also be hazardous to human health, as shown by the increasing occurrence of Lyme disease in the United States. White-tailed deer may carry tiny ticks that are smaller than the head of a pin. The ticks in turn carry a bacterium, *Borrelia burgdorferi,* which causes Lyme disease. The ticks attach themselves to people walking through infested areas. The ticks' bite transfers the bacteria to humans.

A reddish rash shaped like a bull's eye usually appears within days of the tick's bite. Other early symptoms of Lyme disease may include fatigue, fever, chills, and headache. Left untreated, the disease can inflame the heart muscle and nerves or cause painful arthritis in the joints. Antibiotics, if taken soon after symptoms appear, are an effective treatment for Lyme disease. In 1998, the U.S. FDA approved a vaccine for Lyme disease, but it was taken off the market in 2002.